Fermilab
50 Years of Discovery

Status of studies from HPAr TPC

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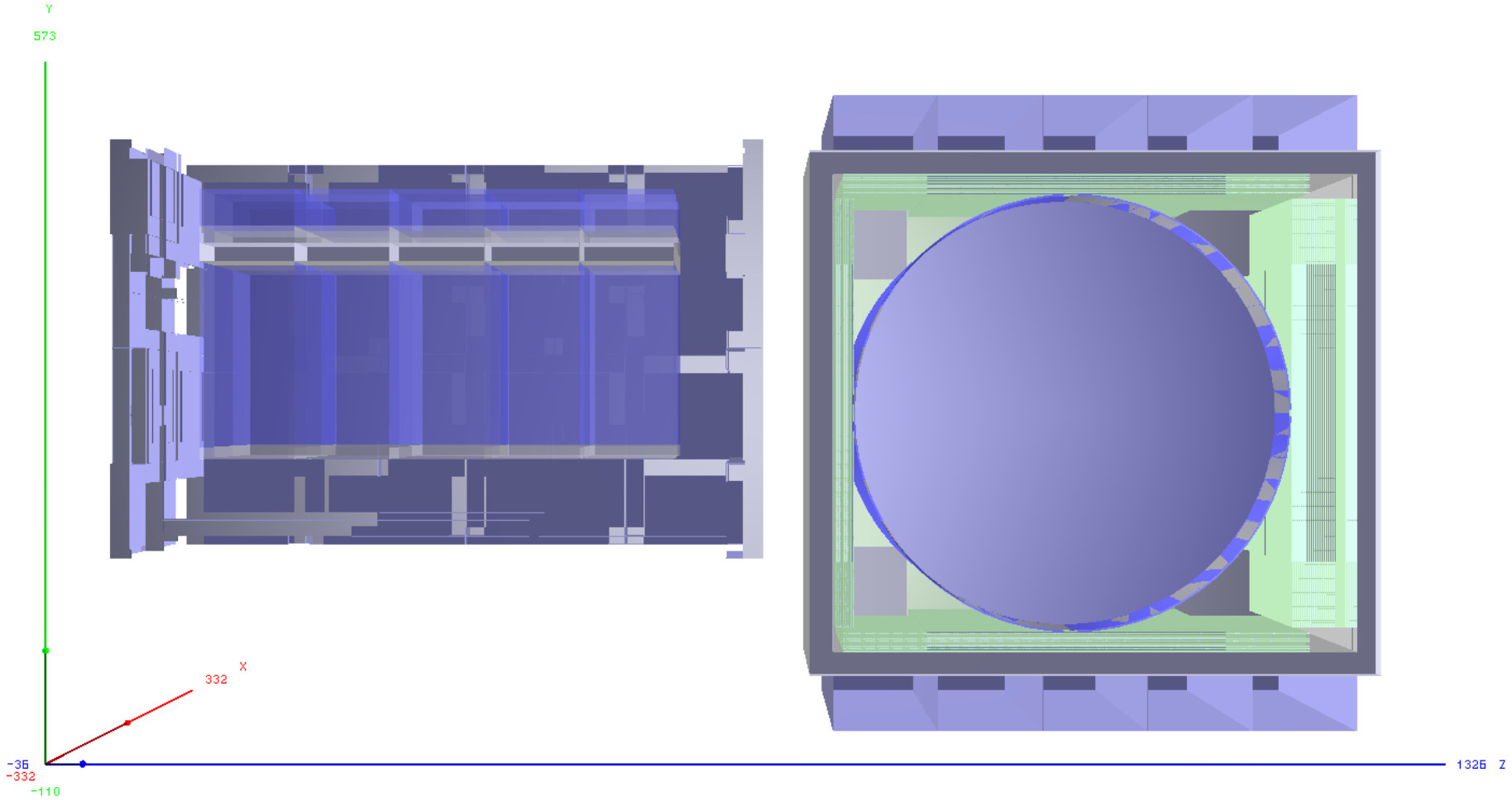
High-pressure Ar gas TPC (HPgTPC) status

- Much progress has been made in last 2 months on the design and performance simulation
  - This is a work in progress, however, with more to be done
- Basic configuration now in simulation framework (J. Lopez)
  - 5 m diameter X 5 m long TPC (copy of ALICE)
    - 1.8T active, 1t fiducial fits in Dipole the size of that in CDR
- Preliminary ECAL design (F. Simon)
  - Two-segment design; one inside pressure vessel, one outside
- Preliminary pressure vessel design (R. Flight)
- Report in DUNE DocDB: DUNE-doc-6652-v1
- The following slides will be a very brief overview

Baseline configuration in DGGsim



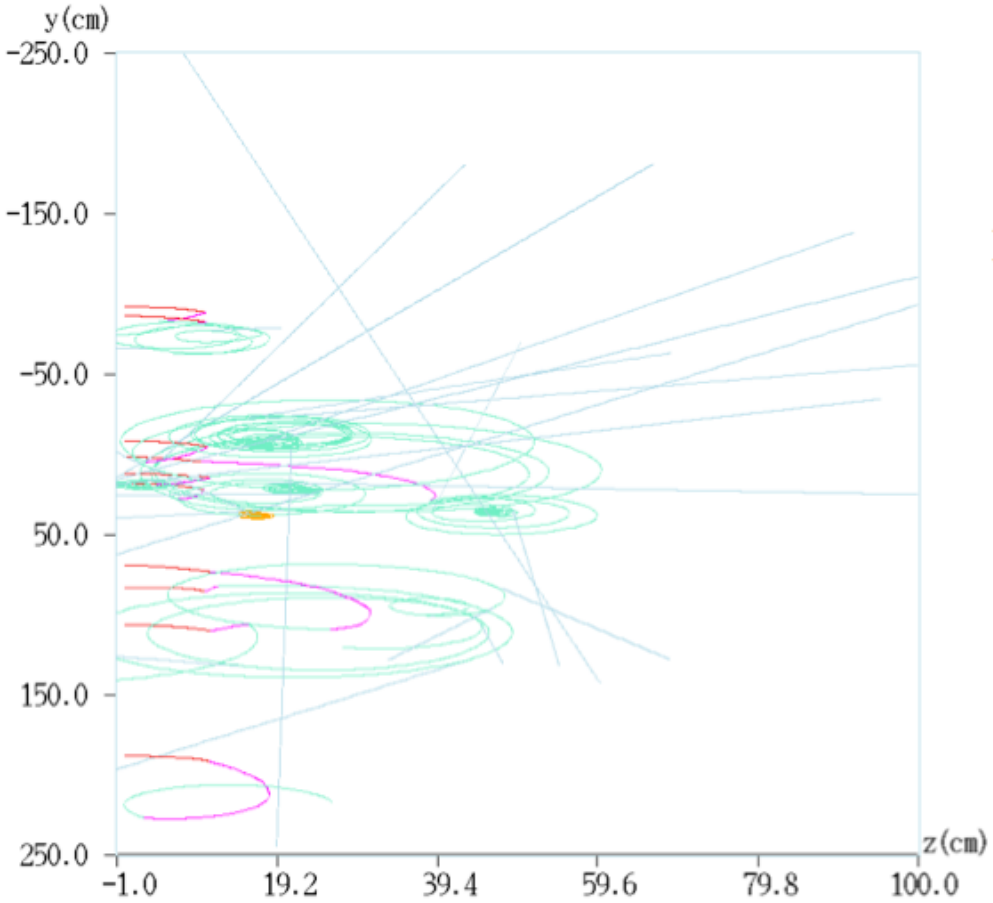
Performance criteria

Parameter	Value	units
σ_x	250	μm
σ_y	250	μm
σ_z	1500	μm
$\sigma_{r\phi}$	<1000	μm
Two-track separation	1	cm
Angular resolution	2-4	mrad
σ(dE/dx)	5	%
σ_{pT}/p_T	0.7	% (10-1 GeV/c)
σ_{pT}/p_T	1-2	% (1-0.1 GeV/c)
Energy scale uncertainty	$\lessapprox 1$	% (dominated by δ_p/p)
Charge particle detection thresh.	5	MeV (K.E.)
ECAL resolution	$5\text{-}7/\sqrt{E/\text{GeV}}$	%
ECAL pointing resolution	$\simeq$ 6 at 500 MeV	degree

Event statistcs: 1 yr. exposure

Event class	Number of events per ton-year
ν_μ CC Total	1.64×10^6
ν_μ NC Total	5.17×10^5
ν_μ CC Coherent	8.35×10^3
ν_μ NC Coherent	4.8×10^3
ν_μ - electron elastic	135
ν_μ CC π^0 inclusive	4.47×10^5
ν_μ NC π^0 inclusive	1.96×10^5
ν_μ Low ν (250 MeV)	2.16×10^5
ν_μ Low ν (100 MeV)	7.93×10^4
$\bar{\nu}_\mu$ CC Coherent ($\bar{\nu}$ mode)	6.90×10^3
ν_e CC Total	1.89×10^4
ν_e NC Total	5.98×10^3
ν_e CC Coherent	93
ν_e NC Coherent	52

Charged-particle track threshold

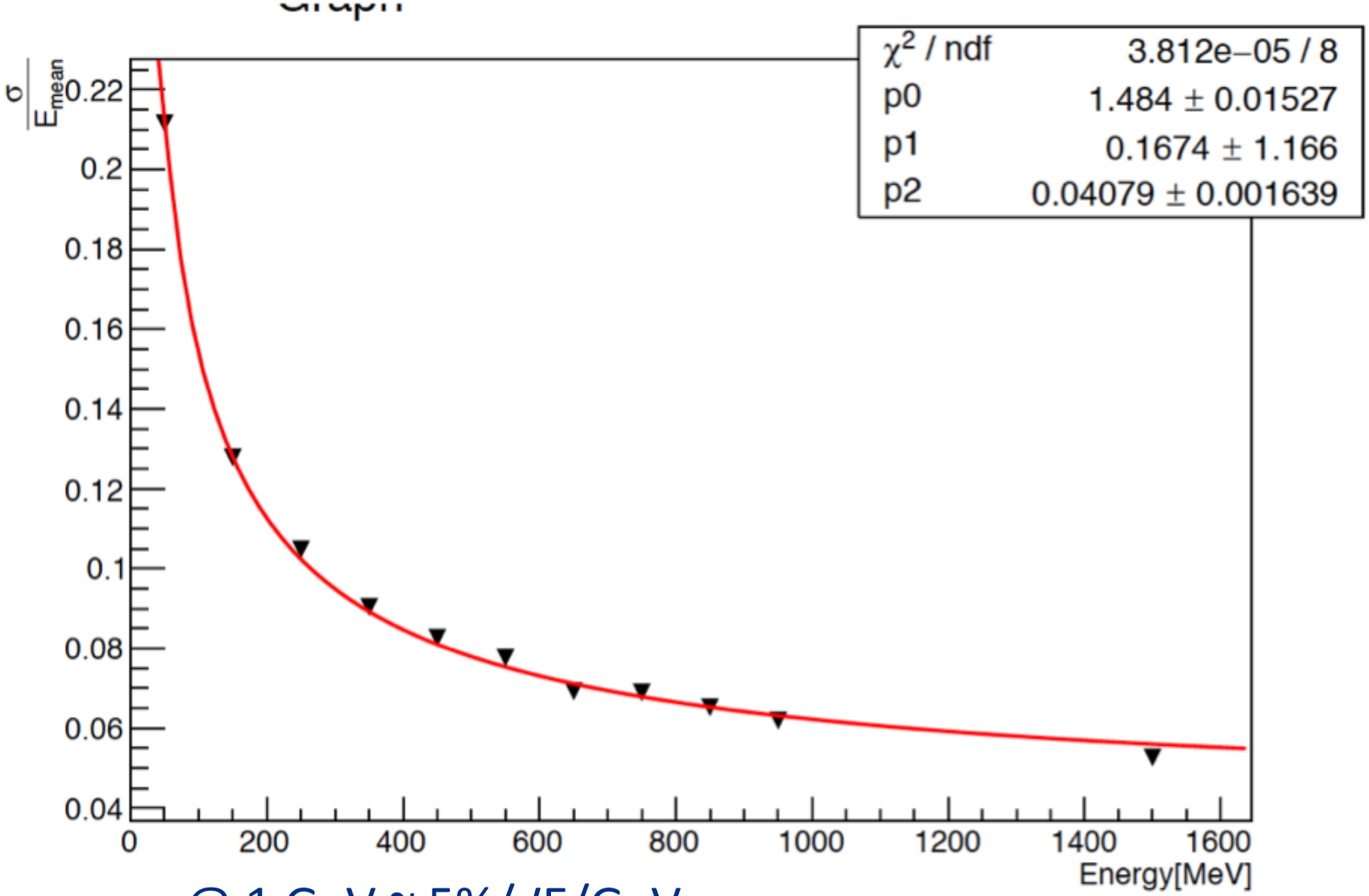


Mean track length (cm), 5 MeV K.E..

Species	Length (cm)
Protons	3
π^+	10
π^-	10
μ^+	15

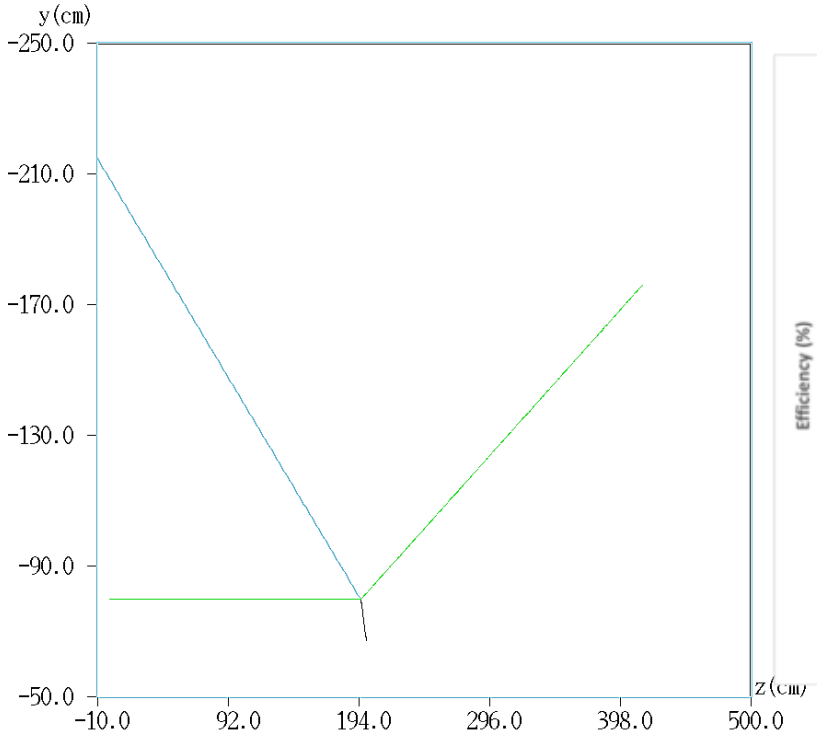
5 MeV K.E. π^+

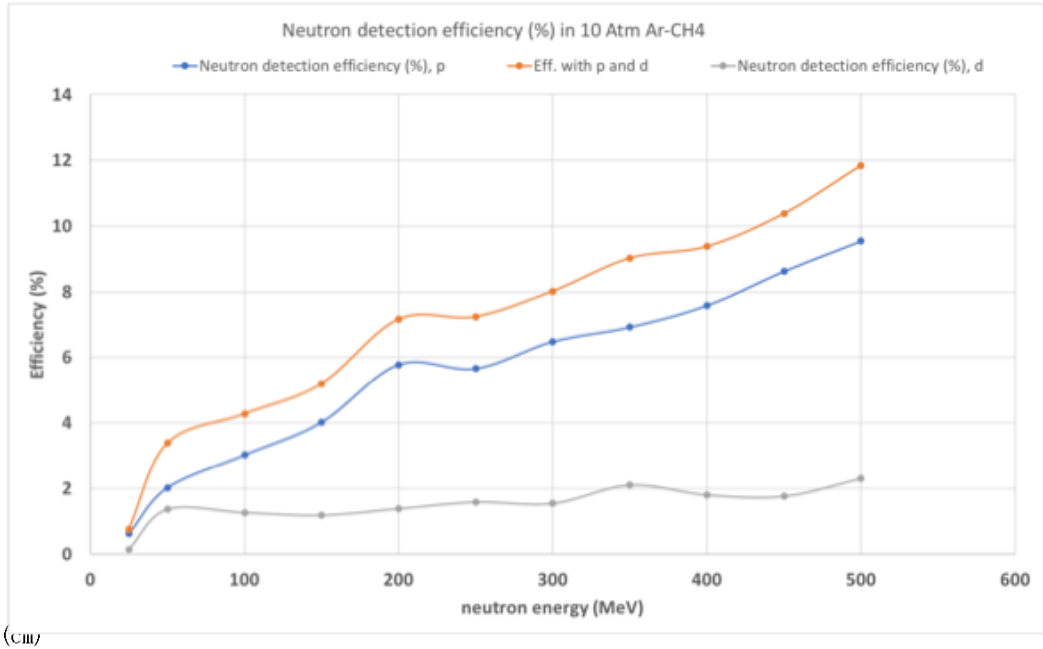
ECAL energy resolution



@ 1 GeV ~ 5%/√E/GeV

Neutron detection





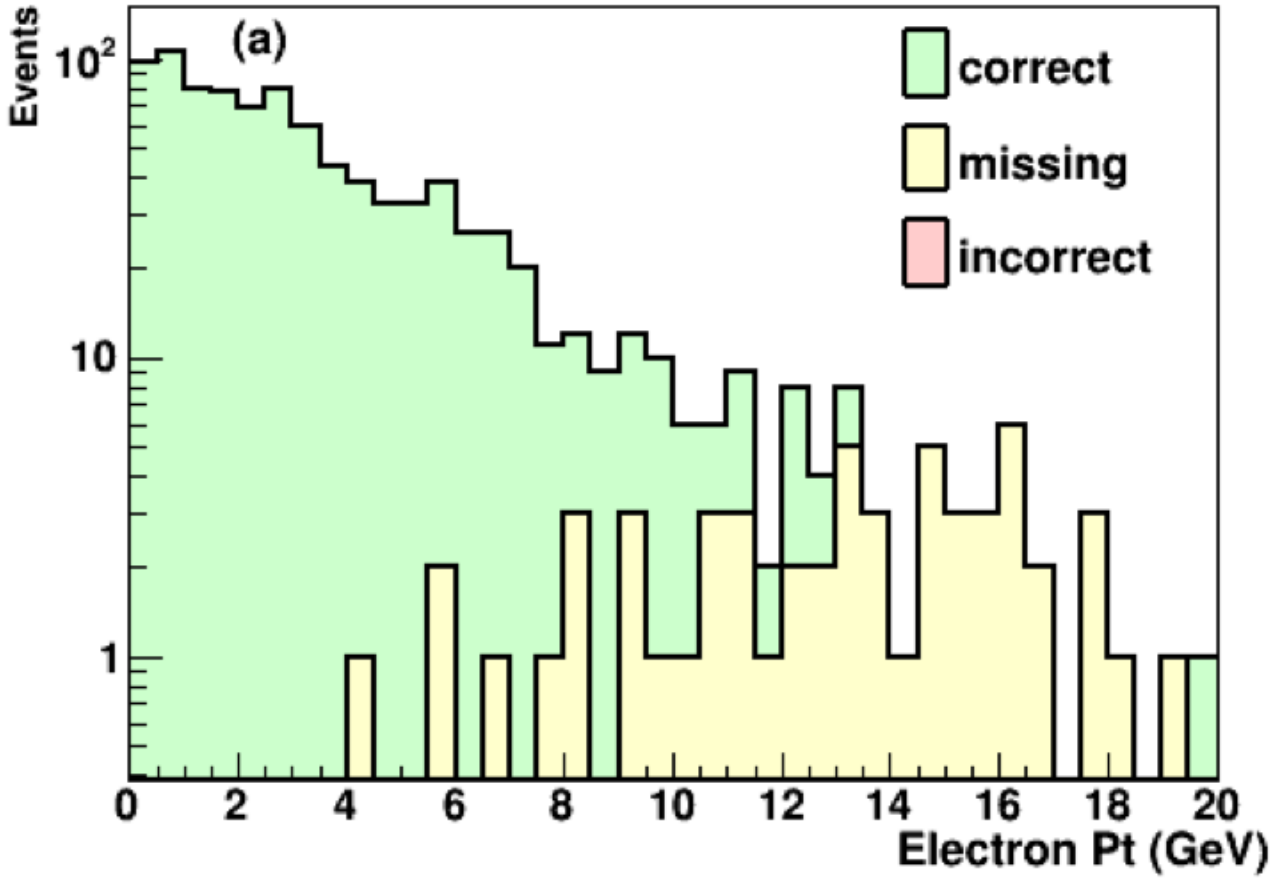
Detection efficiency is low, but event "fidelity" superb.

Commentary:

Using the suite of DUNE near detectors to measure "missing energy", will be tremendously challenging. *(At least if one believes MARS and NIST range tables.)*

More on this in some future meeting.

Electron sign determination



Low-ν events

- Fraction of events that would be classified as low-, assuming detection threshold for charged particles in a LArTPC is 40 MeV. For the HPgTPC, a conservative threshold of 5 MeV and an improved threshold of 2.5 MeV.

	Low-ν [$E_{\text{had}} < 250$ MeV] Events (Sample Purity)	Low-ν [$E_{\text{had}} < 100$ MeV] Events (Sample Purity)
True visible E_{had} (no cuts)	268523 (1.0)	137479 (1.0)
LArTPC ($E_{\text{thresh}} = 40$ MeV)	283226 (0.95)	154884 (0.89)
HPgTPC ($E_{\text{thresh}} = 5$ MeV)	269072 (0.998)	138385 (0.993)
HPgTPC ($E_{\text{thresh}} = 2.5$ MeV)	268665 (0.999)	137720 (0.998)

Towards a fully Argon detector design: iArDet

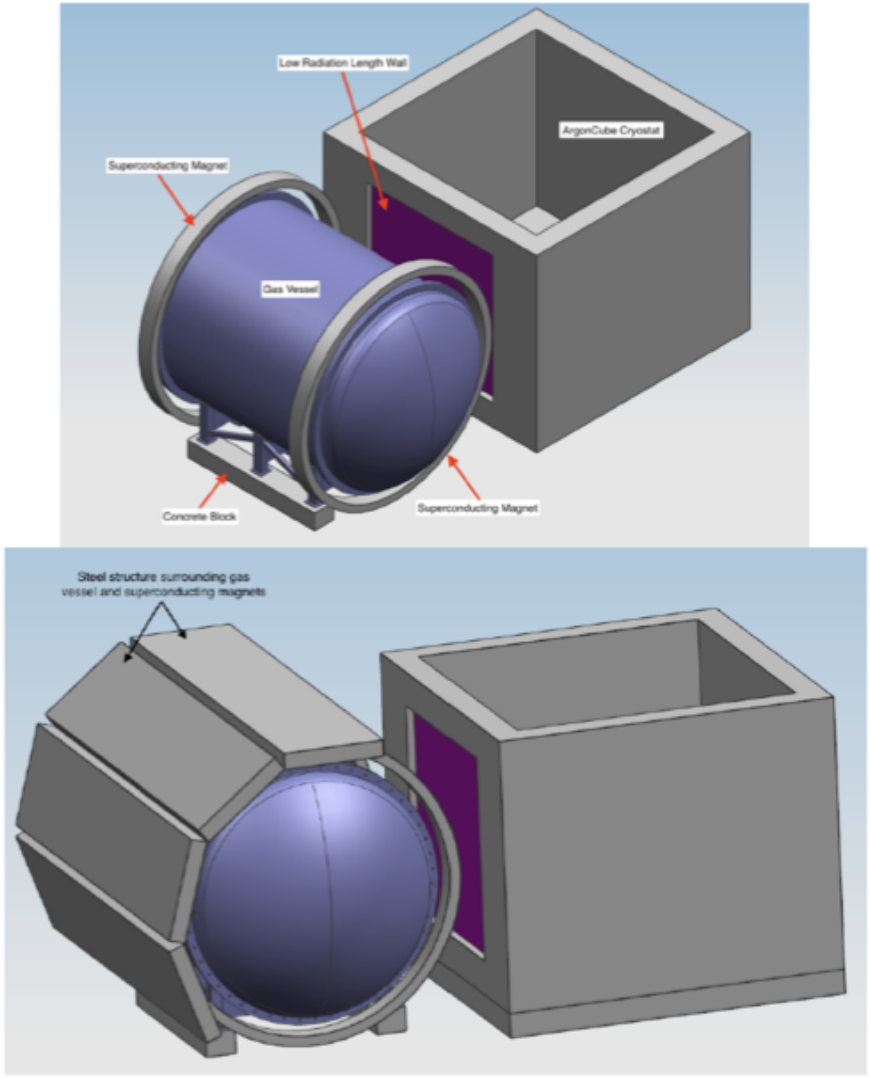


Figure 2: ArgonCube cryostat and gas vessel (top) and depiction of steel shielding around magnets (bottom)

- Features:
  - Cryostat wall replaces concrete with carbon fiber
    - $3X_0 \rightarrow 0.3X_0$
  - Room Temp coils replaced by two SC coils in Helmholtz configuration
    - $\sim 20X_0 \rightarrow 0X_0$
  - Yields non-uniform field
    - TPC tracking in non-uniform (60%) established by NA49
      - Requires mapping and simulation (Opera/Tosca)